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November 1, 1974 - April 30, 1975

APPLICATION OF REMOTE SENSING TO STATE AND REGIONAL PROBLEMS

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April 30, 1975

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I. INTRODUCTION

The primary purpose of the Remote Sensing Applications Program is for various members of the university community to participate in activities that improve the effective communication between the scientific community engaged in remote sensing research and development and the potential users of modern remote sensing technology. The state-of-the-art remote sensing capability is significantly beyond the present-day applications of the potential user group. The program serves to accelerate the use of state-of-the-art remote sensing capabilities which will help to insure reasonable pay-off from and better usage of space, high altitude, and other remote sensing products largely evolved by the NASA program.

Activities of this program are assisting the State of Mississippi in recognizing and solving its environmental, resource and socio-economic problems through inventory, analysis, and monitoring by appropriate remote sensing systems.

In order to achieve this purpose, the participants in this program and collaborating departments are interacting with state and federal agencies, councils of government, counties, and urban groups in the following ways:

1. Identifying and updating state and local problems which remote sensing can help to solve.
2. Assisting potential users to learn how to better use remote sensing where it is appropriate to the solution of specified problems.
3. Conducting remote sensing applications programs to bring remote sensing technology to bear upon the solution of selected high priority problems.
4. Identifying additional research needs to which remote sensing technology may be applied and establishing priorities for meeting these needs.
5. Stimulating, guiding, and aiding the faculty and students at Mississippi State University and others in the State of Mississippi to utilize information from the NASA Earth Resources Satellite and Aircraft Programs in research and public service activities. This program is augmented by cooperation with the EROS Users Assistance Center, National Space Technology Laboratories at Bay St. Louis, MS, and the Marshall Space Flight Center at Huntsville, AL.
6. Provide a center of expertise and an operational laboratory for short-course training, assistance to departments and agencies in utilizing appropriate remote sensing technology in solving their problems (Appendices A - E) and making certain specialized equipment available to users.

Program participants consist of interested faculty researchers in the multifaceted aspects of the application of remote sensing techniques to problems in Mississippi, the region, the nation, and the world. The program participants are organized so as to help foster the growth and improved effectiveness of the group and strive toward accomplishing the purposes of the program.

C. W. Bouchillon, Director of the Institute for Environmental Studies, is serving as Principal Investigator, and W. Frank Miller, Associate Professor of Forestry, is serving as Program Coordinator. Other key personnel in the program include: C. A. Taylor and J. C. Harris, Landscape Architecture; Frank Whisler and Judy Young, Agronomy (Soils); Randel Robinette, Assistant Professor of Wildlife and Fisheries; V. L. Zitta, Assistant Professor of Civil Engineering; and Brad Carter, Assistant Professor of Computer Science.

II. PROJECT PROGRESS REPORTS

A. Bark Beetle Project - Copiah County

Objective

The objective of this study is to provide information to the Mississippi Forestry Commission on the location of high-risk pine stands; that is, those stands which have a high risk of bark beetle attack due to high stand density and/or internal water stress.

Accomplishments

All infestation spots visible on the 1:24,000, color infrared, June 1974, positive tranparencies have been mapped.

A paper was prepared and presented at a remote sensing symposium (Appendix E).

Current Status

Work is in progress to map the site and stand conditions at each of the identified infestation spots. From an analysis of these data, criteria will be developed which will be utilized to designate stands which are considered to be "high-risk" beetle infestation stands. These stands will be mapped on mylar.

Upon receipt of the June, 1975, imagery, new beetle spots will be identified and mapped on mylar. A comparison with predicted sites will permit a statistical evaluation of the probability of correctly predicting high-risk stands.

B. State Park Location - Adams County

Objective

The objective of this project is to provide information to the Mississippi Park Commission which will enable their planners to perform intensive planning on an area in western Adams County which has been selected as the location of a new State park.

Accomplishments

Using the four potential park sites provided by the Applications Program, personnel from the Mississippi Parks Commission briefly visited two of the areas. Based on this field visit and the computer-generated variable maps, the attractiveness models, and the vulnerability models, Commission planners selected one of the sites as the final location of the State park.

The Park Commission then requested that the Applications Program undertake a more detailed analysis of the site. The data derived from this analysis will be utilized in the final location and planning of each of the park units such as day use, marina, beaches, administrative buildings, etc. Cell size has been reduced to 1 hectare (2.47 ac).

Current Status

1:24,000 color infrared, positive tranparencies of the park site were obtained by Marshall Space Flight Center on April 6, 1974. These data are being utilized to obtain the physical, biological, and cultural variables necessary for site analysis (Appendix A).

Work is in progress to code centroid elevation, aspect, slope, transportation routes, and surface water locations. A base map of 1:12,000 scale has been gridded with 1 hectare cells to cover the park location.

Plans

Work on gathering the data base necessary for the geo-information system will continue. A Zoom Transfer Scope is being utilized to transfer variables directly to the base map. When the system has been completed and placed in the computer, the attractiveness and vulnerability analyses will be made.

C. Waste Source Location and Stream Channel Geometry

Objective

It is proposed in this study to use remotely sensed imagery to reduce the level of effort in obtaining stream channel hydrologic characteristics such as length, depth, width, and velocity. In addition, remote imagery will be used to update United States Geological Survey maps for location of point waste sources. All of this information is for inclusion into mathematical models for present water quality assessment and waste load allocation by the Mississippi Air and Water Pollution Control Commission. As a second objective, the feasibility of using remotely sensed imagery to monitor in-stream water quality will be studied. As a portion of the latter objective, a study was made to determine feasibility of using a hand-held 35-mm camera and color infrared film in order to relate pond coloration as defined by Munsell Color chips with total, inorganic and organic solids.

Accomplishments

A literature search was made to determine if hydrologic characteristics of stream channels have been or could be obtained from remote imagery at low flow conditions. Also, the techniques for the location of waste outfalls into stream channels and under what conditions were examined. Hydrologic data required for input into mathematical models are channel length, depth, width, and velocity. The literature search revealed methods for the determination of channel length, top width, and slope are readily obtained from remotely sensed data. Accurate quantitative depth measurement has not been demonstrated. Velocity determinations require placing a photographically reproducible dye tracer or surface floats coordinated with multiple time lapse imagery. Waste outfall location structures are most easily located on large scale photographs taken in the absence of foliage under low streamflow conditions. Updating of these waste outfall structures on USGS maps through remotely sensed imagery has been advantageous.

With respect to the second objective, water quality determination as defined by 35-mm color IR imagery, statistical analyses were run and statistically significant correlations were found between suspended solids and Munsell Color notation of pond color. The results are given in Appendix B.

Current Status

This project has been terminated.

D. The Yazoo-Little Tallahatchie Flood Prevention Project - Grenada, Calhoun Counties

Objective

The objective of this project was to demonstrate the applicability of high-altitude, color infrared imagery in location of sites which require planting for erosion control. Since the YLT Flood Prevention Project has the responsibility for watershed protection in a 19-county area, sites which are undergoing either sheet or gully erosion must be controlled by planting loblolly pine for best results.

Accomplishments

The following data products were obtained for two test counties: 1:120,000 positive transparencies, 1:60,000 paper prints, and 1:30,000 paper prints. Representative erosive sites were visited in each of the counties, and then examined on each of the data products. An interpretation key was developed that would identify sites with a high probability of being in need of planting. The two counties were then examined using both the transparencies and the 2X enlargements, and a total of 46 sites were identified of which 65% were verified by field check of the transparency sites and 55% of the print-identified sites.

Therefore, the transparencies were accepted as being the most accurate data product. The study was performed under conditions which are likely to occur in actual practice; that is, a technician was briefed on interpretation procedures for approximately two days in the field, two days in the laboratory, and then allowed to begin identification of potential sites. It is felt that accuracy of identification can be appreciably improved with additional training.

Current Status

The final project report is in the process of being reviewed by the Project Foresters who were involved in the two study counties.

Plans

Upon report completion, a training session will be held for all Project Foresters and technicians who will be involved in completing the task of site identification in the remaining 17 counties. Only a minimum amount of time will be required in a consulting capacity after the training session.

After this training session this project will be terminated.

E. A Soil Resource Inventory of a Portion of a National Forest

Objective

To demonstrate the capability of high-altitude imagery in providing the data needed for long-range, unit planning on National Forests. The data would provide the information necessary for evaluation of forest and wildlife habitat quality, and recreational planning.

Accomplishments

Color infrared positive transparencies of scale 1:120,000 have been obtained for Unit 33, Bude District, Homochitto National Forest. One preliminary ground truth field trip has been made to begin the evaluation of soil-geology-vegetational relationships which occur. Winter photographs of scale 1:15,840 have also been obtained from the U. S. Forest Service.

Current Status

Only a limited amount of time will be expended on preliminary analysis until the end of the spring semester.

Plans

At the first opportunity, intensive ground truth collection will be initiated and data will be gathered concerning ecological relationships. These data will

serve as the basis for mapping, both from high and low altitude imagery. The maps will then be converted to a geo-information system. The system will then be queried by means of various matrices to establish soil resource divisions, forest and game habitats, and recreational potentials.

F. Forest Resource Inventory of Sixteen-Section Lands - Copiah County

Objective

The objective of this project is to outline a procedure which will provide the Mississippi Forestry Commission with an easy but rapid method of updating 16th section inventories. The purpose of the up-date is to provide the information necessary for proper management of the State's forest resource.

Accomplishments

Approximately 1/3 of the necessary ground truth information has been accumulated to date. Again, the major thrust in field work will be delayed until the end of the present semester. However, approximately 90% of the sections have been mapped on the basis of stand condition classes which are being used for sample stratification. The mapping has been done on 1:24,000 color infrared imagery taken June, 1974; this imagery is also being utilized as the data base for the Bark Beetle Project.

Current Status

The remaining 10% of the section will be mapped in the near future.

Plans

Based on the aerial mapping, stratification will be completed and the remaining ground truth obtained during the summer. The statistical analyses will follow. When the report is completed, a training session will be held for the County Foresters in order to demonstrate how the models can be used for the remainder of the State.

III. LIST OF SPECIAL ASSISTANCE OFFERED

A listing of assistance provided to various users since Semi-Annual Report No. 2 is given in Appendix C. With the large data file available, and increasing awareness of the availability of these data, an increase in use of the Applications Laboratory is anticipated.

IV. SHORT COURSES AND WORKSHOPS

The second workshop presented was designed to provide representatives of State Geological Surveys with a working knowledge of the capabilities and limitations of various types of imagery as applied in the area of geological surveys with emphasis on environmental geology. The program for the workshop and an attendance list are provided in Appendix D.

A third workshop is being considered for the summer. This workshop will deal with the use of a computerized geo-information system as applied in the area of planning and resource management.

V. MISCELLANEOUS PROJECT-RELATED INFORMATION

A list of workshop participation and papers presented at various symposia are listed in Appendix E.

APPENDIX A

Variables Obtained for the Natchez State Park Geo-Information System

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A i

THE NATCHEZ STATE PARK GEO-INFORMATION SYSTEM
Phase 2

Cell size = 1 hectare (2.47 ac.)

Aerial data base: 1/24,000 (approx.) color infrared, April, 1974.
Obtained from NASA MSFC.

Physical and Biological Site Factors

Variable #	Data Card Column	Variable	Code
	1 - 3	North Coordinate	
	4 - 6	East Coordinate	
#1	7 - 9	Centroid Elevation	nearest 10'
#2	10	Aspect	
		less than 3% slope	1
		North	2
		Northeast	3
		East	4
		Southeast	5
		South	6
		Southwest	7
		West	8
		Northwest	9
#3	11	Slope Percent Class	
		0 - 3	1
		3 - 7	3
		7 -12	5
		12-20	7
		20-40	8
		40+	9
#4	12	Topographic Position	
		Upland ridge	1
		Upland ridge, flat	2
		Upland upper slope	4
		Upland lower slope	5
		Terrace	6
		Alluvial plain	8
		Swamp or marsh	9

#5	13	Soil Character	
		Medium texture, non-eroded	1
		Medium texture, eroded	2
		Fine texture, non-eroded	5
		Fine texture, eroded	6
		Coarse texture, non-eroded	7
		Coarse texture, eroded	8
		Gullied lands	9
#6	14	Soil Water Regime	
		Moist, moderately to WD	1
		Droughty, somewhat excessive	3
		Wet, poorly to SPD	5
		Ponded, very poorly drained	9
#7	15	Surface Water	
		3rd order stream	1
		2nd order stream	2
		1st order stream	4
		river 150'	6
		lake (more than 10 ac.)	7
		pond	9
#8	16	Forest Stand Composition	
		Pine - hardwood	1
		Hardwood	3
		Pine	5
		Open (less than 17% cover)	7
		Exceptional Tree	9
#9	17	Forest Stand Density Class	
		over 75% closure	1
		50 - 75% closure	3
		25 - 50% closure	5
		17 - 25% crown closure	7
		Open (less than 17% cover)	9
#10	18	Forest Stand Condition Class	
		Unevenaged sawtimber	1
		Evenaged sawtimber	2
		Unevenaged poles	4
		Evenaged poles	5
		Unevenaged reproduction	7
		Evenaged reproduction	9

Cultural Site Factors

#11	19	Agricultural Activity	
		Groves and orchards	1
		Pasture	3
		Row cropping	5
		Chicken operation	7
		Cattle feeder operation	8
		Catfish ponds	9
#12	20	Minerals and Mining	
		Extractive, abandoned	3
		Extractive	8
		Oil and gas wells	9
#13	21	Structures and Development	
		Mobile home	1
		Single family	2
		Multi-family	3
		Cemetary	4
		Institutional	5
		Commercial	6
		Utilities	7
		Industrial	8
		Sewage treatment	9
#14	22	Within Park Transportation and Rights-of-way	
		abandoned logging or woods	1
		logging or woods road	2
		improved dirt	3
		2-lane unimproved	4
		2-lane improved	5
		2-lane paved	6
		4 lane	7
		Railroad	8
#15	23	Rights of way	
		gas or oil pipelines	1
		REA lines	3
		transmission lines	5
#16	24	Location of Proposed Lake	
		within cell at 260 feet level	1
		within cell at 280 feet level	5

A 1

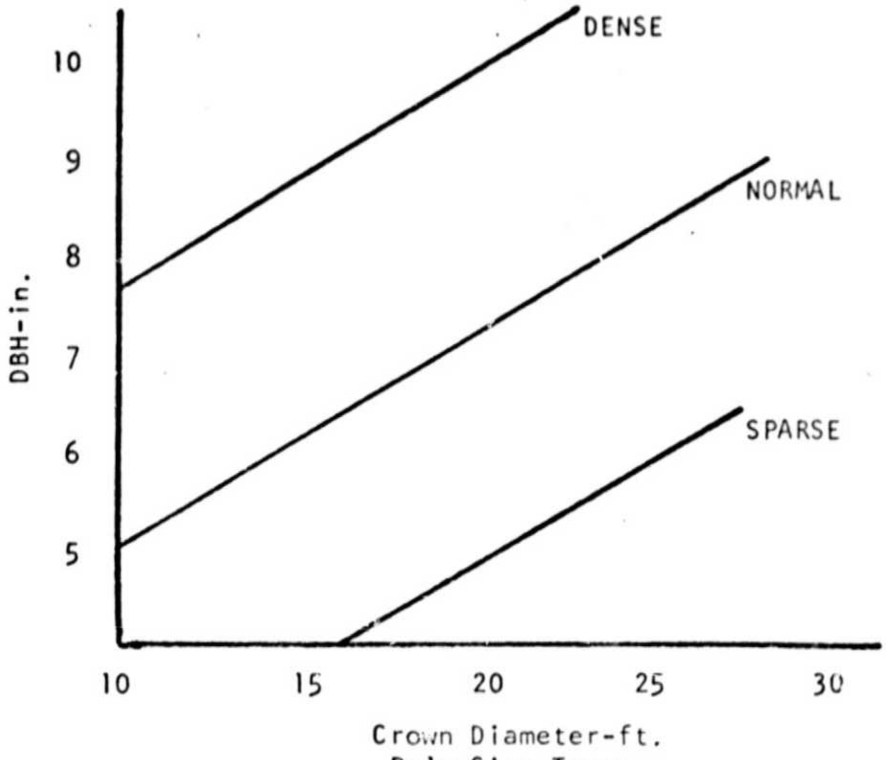
INSTRUCTIONS FOR USE IN INTERPRETING VARIABLE CHARACTERISTICS - NATCHEZ PARK GEO-INFORMATION

Variable #	Variable
1	Centroid Elevation - the average elevation, above sealevel, of the cell. Interpolation may be necessary. Use quad sheet.
2	Topographic Aspect - the direction in which the dominant slope of the cell is facing. In the event of multiple slopes, use the controlling or dominant slope of the general area. From photos.
3	Slope Percent Class - determined from quad sheet; vertical rise/horizontal distance. Based on major slope direction for the cell.
4	Topographic Position - swamp, marsh, and terrace are the bottomland positions; upland ridge flat versus upland ridge refers to the relative steepness of the ridge crest. Many of the loessial ridges are flattened on the top.
5	Soil Character - based on broad textural classes, which in turn are based upon superficial drainage patterns. Parallel gully patterns indicate a fine-textured substrate; dendritic, a coarse-textured substrate; and pinnate, a loessial substrate.
6	Soil Water Regime - if cleared land, very poorly-drained soils are dark colored; water may be present. Poorly-drained soils and somewhat poorly-drained soils generally occur on lower slopes where "benches" or flats break the general slope of the sidehill. Fine-textured soils are generally in this category on ridge flats and gentle slopes. Moderately well-drained and well-drained soils occur on upper slopes and ridges of medium-textured soils. The moderately well-drained soils occur and slopes generally less than 6%. Somewhat excessively and excessively well-drained soils occur on ridges and upper slopes of coarse-textured soils.

Variable #	Variable
7	<u>Surface Water</u> - thi·d order streams are intermittent, and form the tertiary branches of a main drain. Second order streams are generally always with some water movement. A first order stream is the tributary of a major drainage system such as a river. A lake is a body of water, not necessarily man-made, having a surface area of 10 or more acres. A pond is less than 10 acres in surface area.
8	<u>Forest Stand Composition</u> - "open land" is an area which is generally abandoned farm land (row crops or pasture) and supports less than 17% stocking of desirable tree species. "Pine" requires that at least 80% of the stand is composed of pine and hardwood that range from 21% - 79% pine species. "Hardwood" requires that at least 80% of the stand is in hardwood species.
9	<u>Forest Stand Density</u> - self-explanatory; compare crown density with the scale on the Zoom 240.
10	<u>Forest Stand Condition</u> - a qualitative estimate of stand structure and size. Even-aged stands of either pine or hardwood generally have a smooth, regular texture. Uneven-aged stands are generally coarse and irregular in texture, particularly if they have been partially cut in the past. To determine whether the stand is regeneration, pole, or sawlog, it is necessary to correlate crown diameter, height and relative density. That is, crown diameter is indicative of tree DBH (diameter 4.5 ft. above ground) if tree density and height is constant. It is necessary to visualize three different relationships: Height- crown diameter- tree DBH for 1. sparse stands, 2. normal density stands, and 3. dense stands. Generally speaking, crown diameter will be larger for a given height and DBH if the stand is sparse.

Variable # Variable

10-Cont.



Pole Size Trees

The texture of the three size classes of even-aged stands would be: regeneration - very smooth and regular; pole - smooth and slightly irregular; sawtimber - coarse and irregular.

CULTURAL FACTORS

11 Agricultural Activity - self-explanatory; chicken operation with one or more long low houses. Cattle feeding operation with feed yard and large sheds.

12 Minerals and Mining - extractive mining operations are considered as "open-pit" type. The difference between active and abandoned can be detected by evidence of recent truck movement in roads and in the immediate vicinity of the pit. Also, drag lines or other pieces of equipment should be visible.

Variable #	Variable
13	Structures and Development - the use of evidence such as piles of raw materials, machinery, loading docks on spur lines, etc., should distinguish between "commercial" and "industrial;" also, the location of the site will aid in differentiation. Included in "utilities" would be transformer stations, gas or oil pumping stations, and power plants.
14	Within Park Transportation & Rights-of-Way - on color IR, paved roads show as a bluish color, and dirt or gravel as a whitish tone. The clarity of the edges of the roads will also aid in identification; paved roads are sharply defined at the edges while dirt or gravel as not as well defined. Width of right-of-way and identification of pylons or transmission towers distinguish between gas and power. REA lines are quite narrow and have more turns and angles than other lines. A railroad is distinguished from a highway or road on the basis of width - the railroad is more narrow, with sweeping vertical and horizontal curves; that is, gentle curves with long tangents. The difference between improved and un-improved two-lane roads can be seen by examination of the edges - improved will have more sharply defined edges, generally a greater width, and gentler curves than the un-improved.

APPENDIX B

Results of the Water Quality Study: Presented at Tullahoma Space Institute

B1

THE USE OF HAND-HELD 35mm COLOR INFRARED IMAGERY FOR ESTIMATES OF SUSPENDED SOLIDS

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Abstract

The Munsell Color System was utilized in an attempt to correlate total suspended solids, inorganic solids, and organic solids with color designations. Sixteen catfish ponds were flown daily for seven days using two hand-held 35 mm cameras with both Kodachrome X and Ektachrome Infrared film. Hue, value and chroma designations were recorded for each pond on each data by three interpreters, and the accepted value was that recorded by at least two of the interpreters. The interrelationships between suspended solids and the color designations were graphically due to a lack of apparent correlation. Multiple regression was then employed to analyze the data. Highly significant correlations were found between hue and value and total and inorganic suspended solids. The regressions were of the form, $Y = b_0 - b_1$ (in Hue) $- b_2$ (Value) $+ b_3$ (Value)^2. In addition, organic solids also tend to mask the inorganic solids-color relationship.

The work was performed under contract NGL 25-001-054 issued by the National Aeronautics and Space Administration, Office of University Affairs.

**Respectively, Program Coordinator, Remote Sensing Applications; Professor of Agronomy; Assistant Professor of Fisheries and Wildlife; Graduate Assistant; Research Associate.

B 2

Introduction

One of the important facets of the Federal Water Pollution Control Act Amendments of 1972 requires "the states to develop a comprehensive and continuing planning process for water quality management. Plans must include not only the point source controls. . . but also controls for diffuse land runoff and other nonpoint sources. Beginning in 1975, the states must submit annual reports to the Environmental Protection Agency that inventory all point sources of pollution, assess existing and anticipated water quality, and propose programs for non-point source control." The reduction of all suspended solids in ponds and streams is the aim of the 1972 Act Amendments; and suspended solids include inorganic particles and organic particles such as algal suspensions. The usual methods of measuring suspensions in water are by grab samples, Secchi disks, or special control devices which pass a proportion of the pond or stream flow through a sample collection device. There are very few methods of analyzing the amount of sediment being eroded from individual fields or watersheds into ponds and streams. A technique must be devised that can quickly pin-point sources of pollution, and yet be applicable for inventory on a state-wide basis.

Although turbidity is considered to be the major source of water pollution, it is difficult to attach a value to this factor. An approximation could be obtained by comparing costs of water treatment plants that would be required to handle different levels of turbidity. However, there is an associated water quality problem area that is subject to pricing - the relation of water quality to losses in production of channel catfish. There are approximately 67,000 acres of water in channel catfish production in the United States, and over 30,000 acres in Mississippi alone. This industry now represents an income of 50 to 60 million dollars to the growers, and the industry is rapidly expanding; at the moment demand exceeds supply. One reason for the supply situation is that the business involves several high-risk problems; one of which is oxygen depletion of ponds leading to fish kill.

Presently, fish farmers are more or less helpless in regard to estimation of oxygen depletion except for what limited pond management techniques the individual farmer can use based upon his own experience. There is little basic knowledge about the sequence of events leading to these problems. Nor is there a reliable method to predict when oxygen depletion will occur. Even when fish farmers follow recommended stocking and feeding rates, some of their ponds are likely to be in trouble before

the summer is over. Furthermore, the problem appears to occur almost randomly - one pond seemingly identical to a second pond will suffer acute problems, while the second pond does not.

When it becomes evident to the fish farmer that his pond is about to undergo oxygen depletion, frequently his stop-gap methods are too late. Clearly, a reliable and convenient method of monitoring ponds in order to have the ability to predict which ponds need special management would be of immense benefit to the farmer and the catfish industry.

Mr. Rodney Henderson, President of the Mississippi Catfish Farmers, recently estimated that the annual loss due to oxygen depletion would amount to 5% of the total pounds produced (personal communication). Assuming a production of 1500 lb./acre, this would be an approximate loss of 2 1/4 million dollars for the industry as a whole; and, in addition to this loss, indirect impacts were a weight gain reduction due to decreased feeding time during periods of low oxygen, and increased susceptibility to disease and parasites.

The objective of this study was to develop an aerial surveillance technique for detection and identification of suspended solids which would be operational for both governmental monitoring organizations and private individuals operating catfish farms.

Procedure

An installation of 16 catfish ponds managed by the Department of Wildlife and Fisheries was utilized as the test area for this work. One of the problems in previous technique development has been a lack of control over a test environment such as a large lake or river; thus, confounding variables were interjected into the studies.

Pond Management

On May 24, 1974, two hundred catfish fingerlings (Ictalurus punctatus) per pond were stocked in nine 1/10-acre ponds and fed experimental rations at three percent of body weight/day. Fish were harvested on October 24, 1974.

Ponds one, two, and four contained small bass (Micropterus salmoides), channel catfish and buffalofish (Ictiobus sp.), and hybrid sunfish, respectively. No management practices were

applied to these 1/10-acre ponds.

Pond 13, which is a 1/4 acre pond, contained larger channel catfish (1-2 pounds), but was not managed for fish production. This pond has not been drained in approximately 3 1/2 years; thus it represents an equilibrated body of water.

Ponds 14, 15, and 16 are also 1/4 acre ponds and were stocked with combinations of buffalofish, grass carp (Ctenopharyngodon idellus), channel catfish, and paddlefish (Polyodon spathula) that totaled 750 fish per pond. A polyculture experiment using various stocking rates of these species was conducted in these ponds.

Management consisted primarily of treating ponds containing very heavy algal blooms (usually Anabaena) with a 0.1 ppm concentration of $CuSO_4$(copper sulfate) in an effort to prevent future massive algal die-offs. If at any time oxygen levels reached 3 ppm or less, all feeding was stopped until oxygen levels in that pond were again above 2-3 ppm. Fresh water was pumped onto a splash board and into ponds exhibiting oxygen depletion problems. Fertilizer (ammonium nitrate, 13-13-0, etc.) was occasionally applied by hand in an attempt to produce a plankton bloom in those ponds where algal recovery was slow.

Due to differences in algal blooming rate, pond management varied. Some ponds received 4 copper sulfate treatments and area considered throughout this report as "Heavy Treatment" ponds. Non-treated ponds are designated as "No Treatment", and the remainder (light treatment) received from 1 to 2 treatments.

Ground Truth Collection

Personnel from the Department of Wildlife and Fisheries were responsible for sampling the ponds for analyses of nitrates and nitrites, dissolved oxygen, carbon dioxide, chlorophyll, pH, phosphates, temperature, and ammonium nitrogen (1). The Department of Agronomy was responsible for analyses of secchi disk reading, total sediments, inorganic sediments, and organic sediments (2).

Water samples were collected at the time of each overflight by personnel from the respective Departments. The top of a nearby watertower was painted blue and green and was included in each frame taken during the over flights.

Aerial technique

Several preliminary flights were necessary in order to check out cameras, shutter speeds, f-stops, and proper flight altitude to encompass all ponds plus the watertower.

Various charter aircraft were utilized, but the sensors were always a pair of 35mm Praktina FX-3 cameras. One camera used Kodachrome X film (ASA 64) with a clear AV filter, and the other a Wratten 12 filter and Kodak Ektachrome Infrared film. The flight altitude selected was 1720 feet a.g.l.

Flights were made at 10:00 A.M. daily from June 25 through July 1, 1974. Several passes were made during each flight in order to obtain different exposures and assure complete coverage.

Interpretive Techniques and Data Analysis

The slides were processed and 5" x 7" prints were made so that a color balance was achieved between all views of the top of the water tower.

Three different interpreters were utilized to compare the pond with Munsell Color Chips (3). If two of the three interpreters recorded the same hue, value, and chroma for a given pond, this became the accepted color. In order to analyze the data statistically, it was necessary to assign a coded value to the hues (Table 1.).

Table 1. Coding of Munsell hues for statistical analyses.

Hue	Coded Value	Hue	Coded Value
10 G	1	5 B	7
2.5 BG	2	7.5 B	8
5 BG	3	10 B	9
7.5 BG	4	2.5 PB	10
10 BG	5	5 PB	11
2.5 B	6	7.5 PB	12

The actual numerical values were used for chroma and value.

All data were programmed for a Univac 1106, and computerized graphical analyses were performed. Transformations were made where necessary, and both simple linear and multiple regression techniques were employed using a Fortran Omnitab program.

Results and Discussion

Comparison of the two films quickly indicated that there was a confounding effect of depth function in the Kodachrome film. A plank painted white with black marks at 6 inch intervals was placed on one pond bank extending into the water. Examination of the slides at 30X magnification indicated a barely perceptible depth function with the infrared film. However, the depth function on the color slides was apparent. In addition, algal blooms were more readily apparent on the infrared film.

Initial graphical analyses of hue, value, and chroma relationships with total, organic and inorganic sediments indicated the chroma appeared to have weak correlation. Subsequent regression analysis confirmed this and chroma was dropped as an independent variable. It should be remembered that the Munsell system resembles a sectioned orange as is shown in Figure 1. While hue indicates color intensity, or relative proportions of one or more colors (10BG, 5B), value is basically a gray scale. Chroma, however, is a more subtle blend of color intensity and gray scale. Thus, it might be expected that within a given hue, the chroma number would be less easily identified than the value designation.

Additional graphical analysis revealed that there were differences in relationships between suspended sediments and colors between ponds having different levels of management. Consequently, the data were analyzed by multiple regression techniques in three groups; heavy treatment ponds, no treatment ponds, and all ponds combined.

Total Suspended Solids

Figure 1 illustrates the relationship between total suspended solids in all ponds and hue and value for a period of 7 days, June 24 through July 1, 1974.

The prediction equation was as follows:

$$\text{Tot. Sed.(ppm)} = 114.48 - 39.94(\ln \text{Hue}) - 8.51(\text{Value}) + 2.44(\text{Value})^2$$

Figure 2. The relation of total solids and Munsell colors by pond treatment groups. The value is held constant at 6.

The relationship was found to be highly significant with an explained variation (R^2) of 43% based on 91 observations. The polynomial term could be dropped with only a 1% decrease in explained variation. The multiple linear form was:

Tot. Sed. = 134.69 - 50.59 (In Hue) + 10.77 (Value)

The average of all ponds was compared with both the non-treated and heavy treatment ponds (Fig. 2). It is noted that the average pond condition and the non-treated ponds are closely related and appreciably lower in total solids than the heavy treatment ponds. The prediction equations for the light and heavy treatment groups are as follows:

No treatment, n = 28
Tot. solids (ppm) = 181.29 - 42.45 (In Hue) - 25.36 (Value) + 4.07 $(\text{Value})^2$

$$R^2 = 0.54^{**}$$

Heavy treatment, n = 18
Y = 448.13 - 59.72 (In Hue) - 118.44 (Value) + 14.33 $(\text{Value})^2$

$$R^2 = 0.69^{**}$$

There may be several reasons for the differential sediment loads for a given hue and value when pond management classes are compared, but the simpliest would be that any treatment with copper sulfate influences the color-suspended solid relationships. This hypothesis is substantiated by noting that within the "average" pond condition 8 ponds received only light treatment and 5 ponds received no treatment.

Additional regression analysis is in progress to determine the relationships between sediments and color solely within the light treatment group of ponds. The values indicated for the sediment loads are, of course, a reflection of only surface loading due to the lack of penetration of the infrared film.

Inorganic Solids

The relationships between Munsell color variables and inorganic sediments were also analyzed. Graphical analysis indicated again that chromas was not a significant variable. The same logarithmic transformation was used for the coded hue, and the polynomial fit for the value (Fig. 3). The resulting

Figure 3. The relation of inorganic solids and Munsell colors for all ponds for a 7 day period.

equation for all ponds was highly significant with an explained variation of 68%. The prediction equation is as follows:

$$\text{Inorg. solids (ppm)} = 155.40 - 50.47\,(\ln \text{Hue}) - 12.72\,(\text{Value}) + 2.52\,(\text{Value})^2$$

If the polynomial term is excluded, the explained variation is reduced by only 3%, and the equation is as follows:

Y = 145.30 - 61.46 (ln Hue) - 7.16 (Value)

The distinction between ponds having different levels of copper sulfate treatment was again recognized, and regression analyses were run for groups (Fig. 4). The relationships are very similar to those for total solids and color.

Figure 4. Comparison of inorganic solids and Munsell color relationships by pond treatment level. The value is held constant at 6.

The prediction equations for non-treated and heavy treatment levels are as follows:

No treatment, n = 28

Inorg. Seds. (ppm) = 151.30 - 44.68 (ln Hue) - 16.38 (Value) + 2.66 $(\text{Value})^2$

$$R^2 = 0.54^{**}$$

Heavy treatment, n = 18

Y = 334.47 - 78.63 (ln Hue) - 67.31 (Value) + 8.90 $(\text{Value})^2$

$$R^2 = 0.88^{**}$$

Organic Solids

Only in the case where all ponds were grouped was significance achieved, and only at the 5% level. Additional transformations are being investigated, but at this point it would appear that the variations in organic solid content are too subtle to be detected by the Munsell System.

It is apparent by a comparison of total solids-color relations with treatment levels that the organic solids load influ-

ences predictive ability. For example, using the average pond condition the Munsell colors accounted for 43% of the variation in total solids, but accounted for 58% of the variation in inorganic solids. When the ponds are compared by management intensity, this interaction becomes even more apparent. Explained variation for color-inorganic solids was 52% for untreated ponds, 58% for the average pond condition, and 88% for heavily treated ponds.

Summary of Conclusions

In spite of the many sophisticated techniques available today, the technique presented here appears to be an operational method for organizations or individuals with limited budgets.

Within the limits of accuracy prescribed by the correlations, it is possible to detect total and suspended inorganic solids within reasonable accuracy. A large quantity of organic solids would tend to reduce the predictive value of the color-sediment relationships.

It is also concluded, in spite of the many technical objectives which can be raised, that if perfected this technique could be developed to sufficient accuracy for large-scale reconnaissance surveys suitable for monitoring of the quality of our rivers and streams.

Since this paper was pr ared, two additional flights have been made in order to verify the prediction equations. The data from these flights will also be used to further investigate the problem of organic sediment-color relationship.

References

[1]Hack Chemical Co. Hack Methods Manual. Hack Chemical Co., Ames, Iowa. 9th ed. 1973.

[2]Taras, M.J., et. al., Editors. Standard Methods for the Examination of Water and Wastewater; American Public Health Association, Washington, D.C. 20036. 13th Edition, 1971. pp. 288-293.

[3]John T. Smith, Ed. Manual of Color Aerial Photography. Amer. Soc. Photogrammetry, Falls Church, VA. 1968. pp.

APPENDIX C

Assistance Rendered by the Applications Lab and Inquiries Received

C1

ASSISTANCE RENDERED BY MSU REMOTE SENSING APPLICATIONS LAB

Date	Individual	Organization	Purpose	Data & Equipment	Duration
May 21-24, 1974	Short Course 10 Participants	Various	Workshop	Mx 192, 215, ERTS All available	40 hours
June, 1974	Summer Camp Students 55 Participants	Forestry MSU	Teaching	Same	64 hours
Nov. 6-7, 1974	13 Participants	Various	Workshop	Same	40 hours
Nov. 25, 1974	J. W. Campbell	Colonial Hunting Club	Road Layout	Mx 192 stereoscope	½ hour
March 14, 1974	Stanley Assoc.	Stanley Assoc.	Tenn-Tom Planning	Mx 192, Zoom 240	1½ hours
April 7, 1975	Hal Armstrong	U.S.F.S.	General Remote Sensing	Various	2 hours

In addition, the Photo-interpretation course students utilized the laboratory during the fall semester; during the spring semester, the Management Plans course students also used the laboratory and imagery. Personnel from the Department of Wildlife and Fisheries have been utilizing imagery and equipment during both semesters.

INQUIRIES RECEIVED FOR INFORMATION ABOUT PROGRAM PUBLICATIONS

Organization	Location
U. S. Geological Survey	Flagstaff, Arizona
Ecology Consultants	Fort Collins, Colorado
Geo-Research	Westwood, Massachusetts
Tulane University	New Orleans, Louisiana
American Society Planning Office	Chicago, Illinois
U. S. Forest Service	Lakewood, Colorado
University of Massachusetts	Amherst, Massachusetts
Colorado State University	Fort Collins, Colorado
Arid Zone Investigations	Mendoza, Argentina
Instituto Brasileiro de Densenvolimiento Florestal	Rio, Brasil

APPENDIX D

Program and Participation in Second Remote Sensing Applications Program

D1

APPLICATIONS OF ERTS AND HIGH ALTITUDE AIRCRAFT IMAGERY IN GEOLOGY
November 6, 1974
Mississippi State University Department of Forestry
and The Institute for Environmental Studies

Office of University Affairs, National Aeronautics
and Space Administration

Faculty

Dan Sapp, Chief
Remote Sensing Section
Geological Survey of Alabama

Gary North, Chief
EROS Experiments and Evaluation Office
Department of Interior

Frank Miller, Assoc. Program Coordinator
Remote Sensing Applications
Mississippi State University

Dr. E. E. Russell, Professor
Department of Geology
Mississippi State University

Participants

Members of State Geological Surveys from Tennessee, Arkansas, Kentucky, Georgia, Oklahoma, and Mississippi are invited, as well as faculty members from the respective Land Grant Universities.

Course Objective

To provide the participants with a working knowledge of the capabilities and limitations of various types of imagery as applied in the area of geologic surveys.

Course Duration

1½ days

Course Content

6 November, 1974

1:30 P.M. Examples of Imagery Applications by the Geological Survey of Alabama. Dan Sapp, GSA.

D2

3:30 P.M. Coffee

3:45 P.M. Geologic Applications - The EROS Program.
Mr. Gary North

5:00 P.M. Adjourn

7 November

8:00 A.M. Terrain Analysis: Interpretations for Environmental Geology. Frank Miller, Mississippi State University.

9:00 A.M. Seminar - Interpretations for Environmental Geologists. Dr. Russell, Frank Miller, Mississippi State University.

10:30 A.M. Workshop Session. Each participant will be provided with ERTS imagery for a portion of his state, and he will produce:

1. a physiographic map
2. an environmental geology map (landscape units)
3. a hydrologic map

ERTS imagery at a scale of 1:1,000,000 and will be provided. Frank Miller, Mississippi State University.

3:00 P.M. Summary

D3

Participants of MSU Remote Sensing Seminar on Geology

Mr. Martin C. Noger
Head, Aerial Geology Mapping
Kentucky Geological Survey
Lexington, KY

Mr. James H. May
Mr. John W. Green
Mr. Michael Bograd
Mr. Wilbur T. Baughman
Mississippi Geological Survey
Mississippi Geological Economic
and Topographical Survey
Jackson, MS

Dr. Louis Dixon
Louisiana Geological Survey
Baton Rouge, LA

Dr. John M. Kaye
Dr. Donald Keady
Dr. Troy J. Laswell
Dr. Ernest E. Russell
Dr. M. W. Meyers
Department of Geology and Geography
Mississippi State University
Mississippi State, MS

Ms. Sharon Kinsman
Mr. George Waldow
Stanley Consultants
Muscatine, Iowa

Mr. William V. Bush
Arkansas Geological Commission
Little Rock, AR

Mr. Jonathan C. Hescock
Bausch & Lomb
Ocean Springs, MS

Mr. Dan Sapp, Chief
Remote Sensing Section
Geological Survey of Alabama
Tuscaloosa, AL

Mr. Gary North, Chief
EROS Experiments and Evaluation Office
Department of the Interior
National Space Technology Laboratories
Bay St. Louis, MS

Dr. E. E. Russell, Professor
Department of Geology
Mississippi State University
Mississippi State, MS

Mr. W. Frank Miller, Associate Professor
Department of Forestry
Mississippi State University
Mississippi State, MS

APPENDIX E

Miscellaneous Project Related Information

E1

Whisler, F.D., Young, J.D., Cannon, T.K., and W.F. Miller. 1974. Aerial surveillance of water quality. Ann. Meeting, Amer. Soc. of Agron. November.

Walls, M.D., and W. Frank Miller. 1974. The use of aerial photographs in archeological site location: an upper central Tombigbee Valley application. 31st Ann. Arch. Conf., October, Atlanta, Georgia.

Miller, W. Frank. 1975. Remote sensing applications in environmental impact studies. Am. Soc. Photo. Remote Sensing Symposium, Athens, Georgia.

Miller, W. Frank, Taylor, C.L., and M.E. Miller. 1975. Remote sensing applications in recreation site location. Am. Soc. Photo. Remote Sensing Symposium, Athens, Georgia.

Miller, W. Frank, Whisler, F.D., Robinette, H.R., Finnie, D., and T. Cannon. 1975. Fourth Ann. Remote Sensing of Earth Res. Conf. Tullahoma, Tennessee.

Miller, W. Frank and Steve Sader. 1975. Characteristics of "high-risk" beetle stands. Third Univ. So. Miss. Seminar in Remote Sensing, Hattiesburg, Ms.

The Program Coordinator was also invited to make a presentation at The Forest Industry Remote Sensing Workshop sponsored by the EROS Program and the MSU/LSU Logging and Forest Operations Center at the National Space Technology Laboratories, Bay St. Louis, Mississippi.

E2

MISSISSIPPI PARK COMMISSION

717 ROBERT E. LEE BLDG./JACKSON, MISSISSIPPI 39201/PHONE (601) 354-6321

March 19, 1975

Mr. Frank Miller
Department of Forestry
Dorman Hall
Mississippi State University
Mississippi State, MS 39762

Dear Frank:

I would like to take this opportunity to express the evaluation of the Mississippi Park Commission concerning the remote sensing computerized geo-information system established for site selection of the proposed park in Adams County, Mississippi.

Site selection criteria seemed satisfactory and appropriate in all categories; and the resulting base, which yielded the computer-produced map, assisted us immensely in the final site selection process.

With the computerized technique, hundreds of man hours were saved, and an infinitely greater number of criteria could be considered, ranked and evaluated. The techniques enabled greater and more careful consideration of site alternatives than would normally be possible. The result has been the assurance that the final site chosen has met all planning criteria in all respects.

I wish to express our continued interest in utilizing remote sensing computer techniques for site selection of future parks as the need arises.

Our sincere appreciation to you and your group for the valuable service performed and hope that we will have an opportunity to work together in the near future.

Sincerely,

Thomas A. Wetzel

Thomas A. Wetzel
Chief of Planning & Design

TAW/sj

E3

ecology consultants, inc.
P.O. Box 1057 • 125 S. College Ave. • Fort Collins, Co. 80522
Telephone: (303) 493-8878

April 14, 1975

Dr. W. Frank Miller
Program Coordinator
Remote Sensing Applications
Department of Forestry
Mississippi State University
P.O. Drawer FD
Mississippi State, Mississippi 39762

Dear Dr. Miller:

Thank you for your letter of April 9 which clarified elements of the remote sensing project we had inquired about.

Our staff members have reviewed the list of publications which you indicated are available, and collectively have asked me to request the following:

Miller, W.F., D. Arver, J.L. Wolfe, R. Altig and J.R. Watson. 1973. An Ecological Study of the Tennessee - Tombigbee Waterway.

__________. 1973. Interpretation of Aerial Data for Ecological Evaluations - The Tennessee - Tombigbee Waterway.

Miller, W.F., M.D. Wells and C. Blakeman. 1974. Applications of Remote Sensing in Archeological Site Identifications

Miller, W.F., L. Calvin and M.R. Miller. 1974. The Application of Remote Sensing to the Identification of Potential Recreation Sites along the Tennessee - Tombigbee River.

Walls, M.D. and W.F. Miller. 1974. The Use of Aerial Photographs in Archeological Site Location: an Upper Central Tombigbee Valley Application.

E4

ECI

Dr. W. Frank Miller
April 14, 1975
Page two

Many of your recent seminar papers appear to have excellent application to current land use problems. I am pleased that Mississippi State University has such a strong remote-sensing orientation.

Again, thank you for your letter, and for sending copies of the above publications.

Sincerely,
ECOLOGY CONSULTANTS, INC.

Stephen G. Martin

Stephen G. Martin, Ph.D.
Vice President

SGM:tlk